BIOASSESSMENT REPORT

RAPID BIOASSESSMENT OF THE

LAKE WAVELAND WATERSHED

USING BENTHIC MACROINVERTEBRATES

May 2000
October 2000

For the
Soil and Water Conservation Districts of
Parke and Montgomery Counties

Study Conducted By:

Greg R. Bright and Amanda S. Cutler
Commonwealth Biomonitoring
8061 Windham Lake Drive
Indianapolis, Indiana 46214
(317) 297- 7713

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EXECUTIVE SUMMARY

A rapid bioassessment technique was used to determine the degree of biological impairment present in five tributaries of Lake Waveland in west-central Indiana prior to implementation of various land treatments in the watershed by the local SWCD offices. Lake Waveland has shown signs of rapidly increasing eutrophication since the 1970s.

The benthic communities of six sites, including a reference site, were sampled during May and October 2000 to provide information on environmental conditions present in the watershed before the treatments are applied. The reference site, Indian Creek, has been identified as an "exceptional use" stream in Indiana due to its excellent habitat and ability to support a diverse aquatic community.

All of the five study sites in the Lake Waveland watershed had biotic index values less than the reference site. These sites showed "slight" to "severe" impacts. The differences were due to both degraded habitat and water quality. The most likely cause of water quality impacts were excessive sediment inputs. Water quality at most sites did not vary significantly between the May and October sampling periods.

Recommendations to improve the condition of the Lake Waveland watershed include bank stabilization using vegetative techniques, limiting access to the stream by livestock, restoring trees along streambanks, elimination of milk waste from one tributary, discouraging extreme stream channelization, and continued biological monitoring to gauge the success of the program after it has been fully implemented.

INTRODUCTION

This study was conducted to measure the "biological integrity" of streams feeding Lake Waveland in west-central Indiana. The streams are tributaries of Little Raccoon Creek in the Wabash River Basin. Lake Waveland is listed by the Indiana Department of Environmental Management (IDEM) as having seriously degraded water quality due to nonpoint sources of pollution such as excessive sediment and nutrient inputs from runoff [1]. The lake's trophic index value (measured on a scale from 0 to 75 in the Indiana lake management program) has increased from 20 to 36 in the past 25 years [24].

To deal with this problem, the Soil and Water Conservation District offices of Parke and Montgomery Counties sought and received a grant from the Indiana Department of Natural Resources to develop a soil conservation plan to help reduce nonpoint source problems in the stream. Prior to implementing the plan, the SWCD office decided to conduct a benthic study of the stream to document "before treatment" conditions.

Local Setting

Lake Waveland, a 360 acre impoundment in the upper Little Raccoon Creek watershed, is located in the "Central Corn Belt Plain" ecoregion of the Central U.S. [2]. The land in the watershed was molded by glacier activity and is relatively flat. The original forests were dominated by beech, maple, oak, and hickory trees but row crop agriculture and livestock grazing are the most common land uses today. In fact, about 95% of the watershed upstream from Lake Waveland is devoted to agricultural uses. Only about 5% remains forested [19].

Little water quality information has been collected in this watershed. IDEM classified Big Raccoon Creek as supporting its designated uses for aquatic life based on agency fisheries data.

Figure 1.

Lake Waveland Area

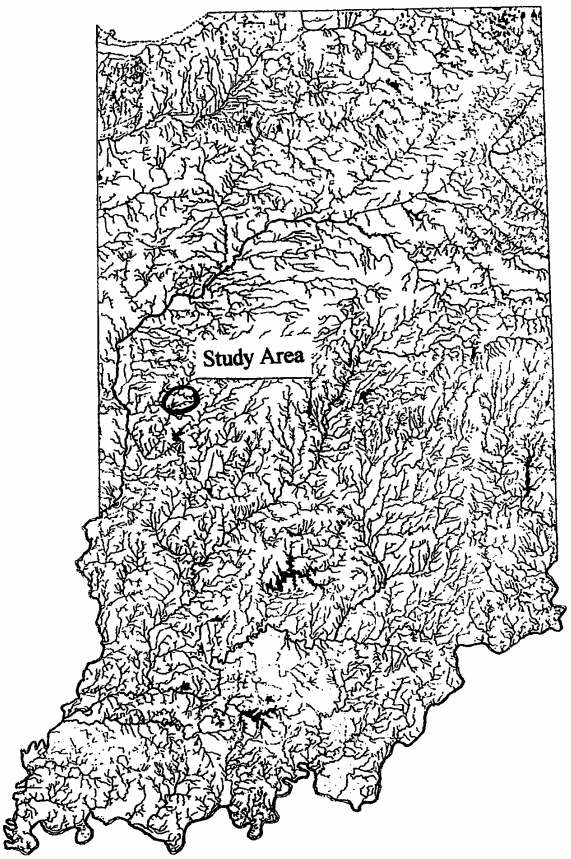
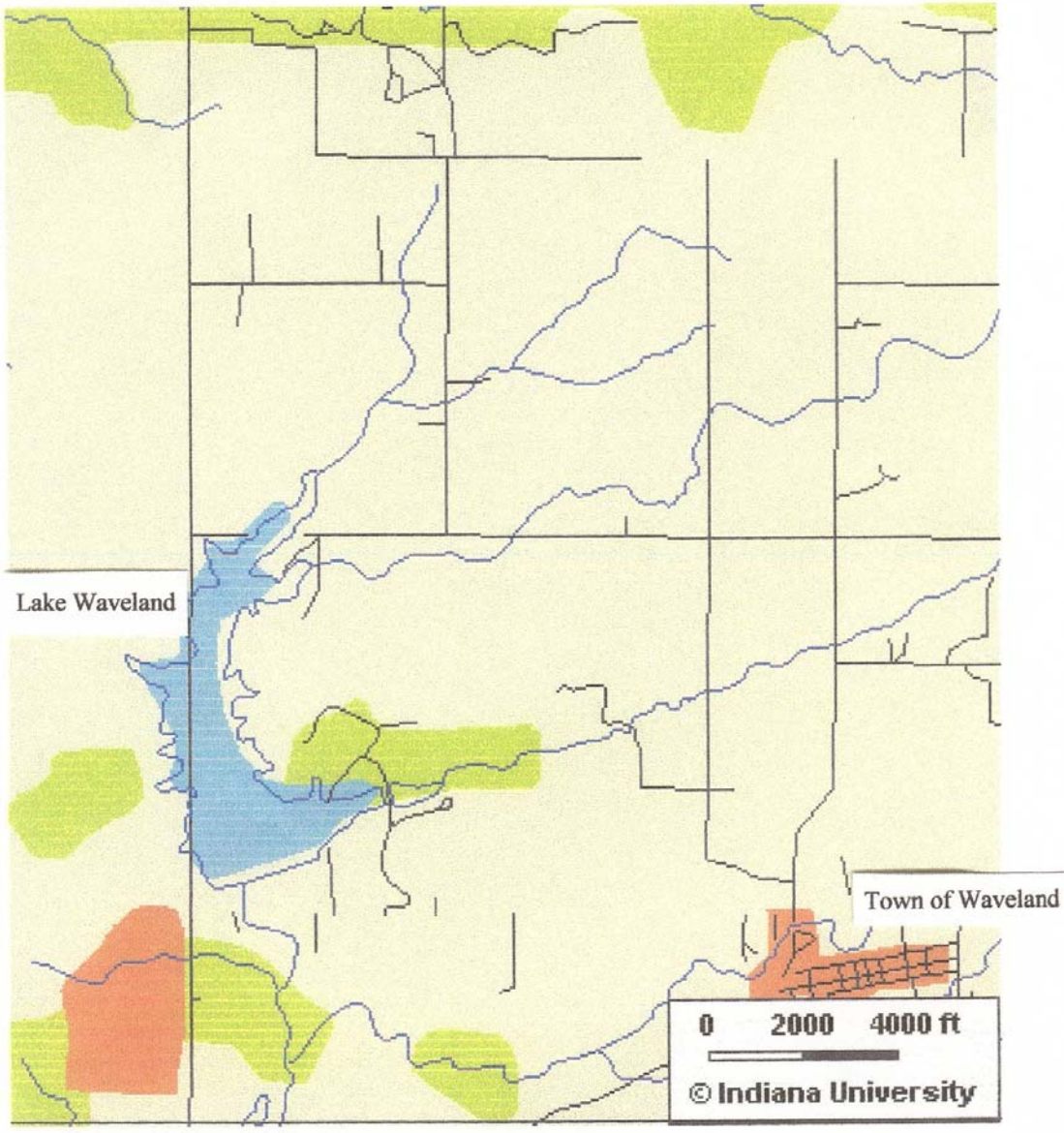


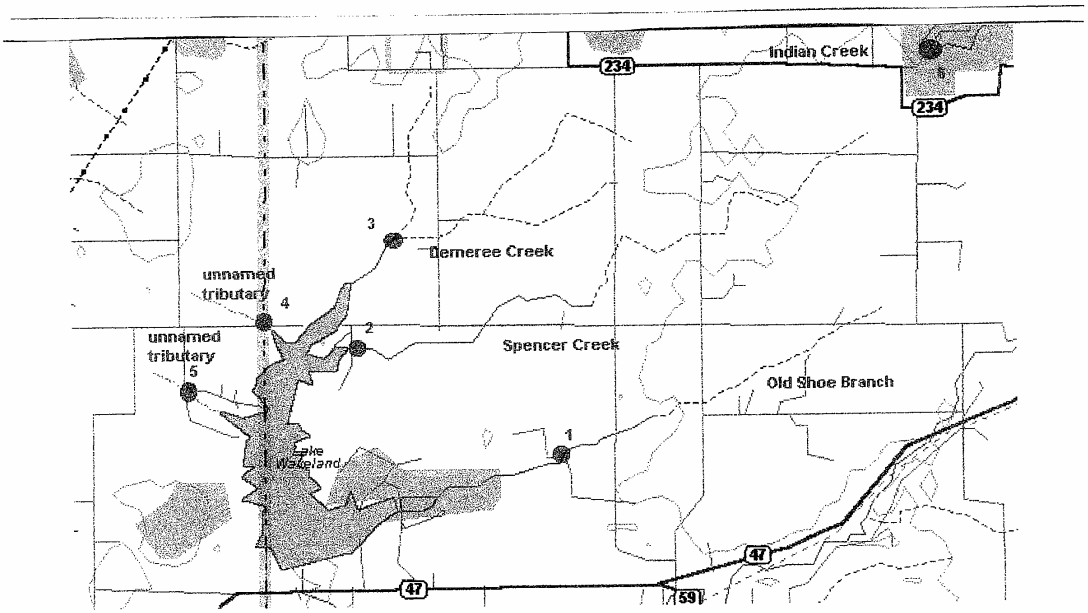
Figure 2.
Land Uses in the Watershed
Green areas are forested, yellow areas are agricultural, orange areas are urban



Six sampling sites were chosen for this study. All of the study and reference streams are "first order" or "second order" streams. Watershed areas of each site [18] and their locations are shown below:

Site 1	**Old Shoe Branch at CR 1050 S**	**5.1 km^2 (2.0 mi^2)**
Site 2	**Spencer Creek at CR 950 S**	**6.4 km^2 (2.5 mi^2)**
Site 3	**Demeree Creek at CR 900W**	**6.1 km^2 (2.4 mi^2)**
Site 4	**Unnamed Tributary on access road**	**1.0 km^2 (0.4 mi^2)**
Site 5	**Unnamed Tributary at CR 950S**	**1.5 km^2 (0.6 mi^2)**
Site 6	**Indian Creek at CR 600W (Reference Site)**	**46 km^2 (18 mi^2)**

Figure 3
Study Sites



METHODS

Because they are considered to be more sensitive to local conditions and respond relatively rapidly to environmental change [3], benthic (bottom-dwelling) organisms were used to document the biological condition of each stream. The U.S. Environmental Protection Agency (EPA) has recently developed a "rapid bioassessment" protocol [4] which has been shown to produce highly reproducible results that accurately reflect changes in water quality. We used EPA's Protocol III to conduct this study. Protocol III requires a standardized collection technique, a standardized subsampling technique, and identification of at least 100 animals from each site to the genus or species level from both "study sites" and a "reference site." CPOM (Coarse Particulate Organic Matter) samples were collected and analyzed to determine the percentage of shredder organisms.

Reference Site

The aquatic community of a reference site is compared to that of each study site to determine how much impact has occurred. The reference site should be in the same "ecoregion" as the study sites and be approximately the same size. It should be as pristine as possible, representing the best conditions possible for that area.

IDEM has classified Indian Creek in Montgomery County as an "exceptional use" stream because it has some of the highest aquatic life and habitat values in the state [20]. Indian Creek has a drainage area which is similar to the study sites and lies only a few miles to the northeast, in the same ecoregion. Therefore, Indian Creek was used as the basis of comparison for all other sites in the study.

Habitat Analysis

Habitat analysis was conducted according to Ohio EPA methods [21]. In this technique, various characteristics of a stream and its watershed are assigned numeric values. All assigned values are added together to obtain a "Qualitative Habitat Evaluation Index." The highest value possible with this habitat assessment technique is 100.

Water Chemistry

Water chemistry measurements were made at each study site on the same day that macroinvertebrate samples were collected. Dissolved oxygen was measured by the membrane electrode method. The pH measurements were made with a Cole-Parmer pH probe. Conductivity was measured with a Hanna Instruments meter. Temperature was measured with a mercury thermometer. All instruments were calibrated in the field prior to measurements.

Macroinvertebrate Sample Collection

Samples in this study were collected on May 17 and October 17, 2000. The first sample represented watershed conditions at the start of the growing season, while the second sample represented conditions after a full growing season had been completed. Site 4 could not be sampled during October because Lake Waveland water levels had risen considerably and the site was under water.

Benthic samples were collected by kicknet from riffle habitat where current speed was 20-30 cm/sec. Riffles were used because they were the most important benthic habitat present at all study sites. The kicknet was placed immediately downstream from the riffle while the sampler used a hand to dislodge all attached benthic organisms from rocks upstream from the net. The organisms were swept by the current into the kicknet and subsequently transferred to a white pan. Each sample was examined in the field to assure that at least 100 organisms were collected at each site. In addition, each site was sampled for organisms in CPOM (coarse particulate organic matter, usually consisting of leaf packs from fast-current areas). All samples were preserved in the field with 70% ethanol. A duplicate sample was collected at Indian Creek for quality assurance purposes.

Laboratory Analysis

In the laboratory, a 100 organism subsample was prepared from each site by evenly distributing the whole sample in a white, gridded pan. Grids were randomly selected and all organisms within grids were removed until 100 organisms had been selected from the entire sample.

Each animal was identified to the lowest practical taxon (usually genus or species). As each new taxon was identified a representative specimen was preserved as a "voucher." All voucher specimens have been deposited in the Purdue University Department of Entomology collection.

RESULTS

Aquatic Habitat Analysis

When the Ohio EPA habitat scoring technique was used, the following aquatic habitat values were obtained for each site in the study:

	Score	% of Reference
Old Shoe Branch (Site 1)	59	68
Spencer Creek (Site 2)	63	72
Demeree Creek (Site 3)	44	51
Unnamed Tribuary - CR 950S (Site 4)	52	60
Unnamed Tributary - CR 950S (Site 5)	49	56
Indian Creek (Site 6)	87	100

The maximum value obtainable by this scoring technique is 100, with higher values indicating better aquatic habitat. Sites with lower habitat values normally have lower biotic index values as well. Details of the habitat scores for each site are shown in the appendix.

The scores indicate that the lowest aquatic habitat value in this study was at Site 3 on Demeree Creek. Habitat at Site 3 was hampered by a paucity of stable bottom substrate and instream cover, by a lack of any riparian buffer zone, and by channelization.

Water Quality Measurements
April 13, 2000

	D.O. mg/l	pH SU	Cond. uS	Temp. (C)
Site 1 (Old Shoe Branch) Time = 2:05 p.m.	10.5	8.2	400	15.5
Site 2 (Spencer Creek) Time = 2:57 p.m.	10.3	8.4	400	18.0
Site 3 (Demeree Creek) Time = 4:22 p.m.	14.6	8.6	400	16.5
Site 4 (unnamed tributary) Time = 3:33 p.m.	9.5	8.4	400	23.0
Site 5 (unnamed tributary) Time = 3:58 a.m.	9.3	8.2	500	17.5
Site 6 (Indian Creek) Time = 5:05 p.m.	10.6	8.9	400	20.0

October 17, 2000

	D.O. mg/l	pH SU	Cond. uS	Temp. (C)
Site 1 (Old Shoe Branch) Time = 2:05 p.m.	11.0	7.7	430	14.0
Site 2 (Spencer Creek) Time = 2:57 p.m.	10.8	7.6	440	13.5
Site 3 (Demeree Creek) Time = 4:22 p.m.	17.2	7.2	470	14.5
Site 4 (unnamed tributary) Time = 3:33 p.m.	Not sampled due to high water in Lake Waveland			
Site 5 (unnamed tributary) Time = 3:58 p.m.	12.6	7.6	470	13.0
Site 6 (Indian Creek) Time = 5:05 p.m.	15.2	8.8	480	14.0

D.O. = Dissolved Oxygen
Cond. = Conductivity
Temp. = Temperature in Degrees Centigrade

QUALITY ASSURANCE DUPLICATE RESULTS

Indian Creek

Sample 1 collected by Amanda Cutler
Sample 2 collected by Greg Bright
Sample Date - 10/17/00

	Actual Data	
	Sample 1	Sample 2
Total Genera	21	18
EPT Genera	7	8
Scrapers/Filterers	2.5	8
% Dominant Taxon	17	46
EPT/Chironomids	18	29
Community Loss Index	0.0	0.4
Hilsenhoff Biotic Index	6.1	6.6
% Shredders	14	8

	IBI Scores	
	Sample 1	Sample 2
Total Genera	6	6
EPT Genera	6	6
Scrapers/Filterers	6	6
% Dominant Taxon	6	0
EPT/Chironomids	6	6
Community Loss Index	6	6
Hilsenhoff Biotic Index	6	6
% Shredders	6	6
Total Score	48	42

Mean Site Score = 45
Each duplicate is within 10% of the mean
Both scores indicate "no impairment"

The quality assurance duplicates provided strong evidence that the bioassessment technique produced reproducible data during this sampling period.

Table 1.
Rapid Bioassessment Results - Lake Waveland Watershed
May 2000

	Site #					
	1	2	3	4	5	6
Chironomidae (Midges)						
Cricotopus trifascia		1				3
C. bicinctus	4	7		3	6	
Orthocladius obumbratus	1					
Eukiefferiella pseudomontana						12
Parametriocnemus lundbacki	6	7		1	37	
Nanocladius spiniplinus		1				
Tanytarsus glabratus	8	3	3	7		
Rheotanytarsus exiguous	2			5		
Dicrotendipes neomodestus	3		5			
Thienemannimyia group		6	41			
Ablabesmyia mallochi	9			13	21	
Natarsia sp.						2
Simuliidae (Blackflies)		7	2	2		
Tipulidae (Craneflies)						
Tipula sp.						1
Antocha sp.	1		1		1	
Ephemeroptera (Mayflies)						
Heptagenia sp.	21	3			1	1
Caenis punctata		2				
Baetis brunneicolor		1				1
Trichoptera (Caddisflies)						
Cheumatopsyche spp.		1				20
Plecoptera (Stoneflies)						
Perlesta placida	7					15
Amphinemura venosa	4				8	11
Acroneuria sp.						1
Odonata (Dragonflies)						
Ischnura spp.			1			
Argia apicalis				1		
Coleoptera (Beetles)						
Stenelmis crenata				8	1	
Stenelmis sexlineata						5
Stenelmis humerus						2
Stenelmis larvae	9	1		2	7	6
Dubiraphia vittata		1		1		
Dubiraphia larvae		2		2		
Optioservus sp.				1	1	
Dytiscus sp.				4		
Dytiscus larvae	8	17	17	14	14	1
Berosus larvae		13	20	5		

Table 1 (continued)
Rapid Bioassessment Results - Lake Waveland Watershed
May 2000

	Site #					
	1	2	3	4	5	6
Isopoda (Pillbugs)						
Caecidotea spp.		7				2
Amphipoda						
Hyalella azteca	11				1	
Gastropoda (Snails)						
Stagnicola exilis		1				
Physella gyrina	5	6	1			11
Gyraulus spp.				4		
Elimia livescens					2	5
Pelycepoda (Clams)						
Sphaerium sp.			1	13		
Turbellaria (Flatworms)				10		
Hirudinea (Leeches)	1	9	2	2		1
Oligochaeta (Worms)						
Tubificidae		3	6	2		
Decapoda (Crayfish)						
Orconectes sp.		1				
Total	100	100	100	100	100	100

Mussel Observations

Numerous dead specimens of the paper pondshell Anodonta imbecilis were present in the mud where Spencer Creek enters Lake Waveland. Both valves were present in all specimens, indicating that a healthy population of the paper pondshell probably exists in Lake Waveland.

Table 2. Data Analysis for 5/00 Samples

METRICS

	Site # 1	2	3	4	5	6
# of Genera	16	20	12	17	11	16
Biotic Index	5.8	7.5	7.8	7.2	5.3	5.2
Scrapers/Filterers	39	2.4	0.3	1.1	17	1.7
EPT/Chironomids	1.0	0.3	0.0	0.0	0.1	2.9
% Dominant Taxon	21	17	41	18	37	20
EPT Index	3	4	0	0	2	6
Community Loss Index	0.5	0.4	1.1	0.7	0.9	0.0
% Shredders	19	6	0	0	4	33

SCORING

	Site # 1	2	3	4	5	6
# of Genera	6	6	4	6	4	6
Biotic Index	6	2	2	2	6	6
Scrapers/Filterers	6	6	0	4	6	6
EPT/Chironomids	2	0	0	0	0	6
% Dominant Taxon	4	2	0	6	2	6
EPT Index	2	4	0	0	0	6
Community Loss Index	6	6	4	4	4	6
% Shredders	6	2	0	0	0	6
TOTAL	38	28	10	22	22	48
% of Reference	79	58	21	46	46	100
Impairment Category	S	S	Sv	M	M	N

N = NONE S = SLIGHT M = MODERATE Sv = SEVERE

Table 3.
Rapid Bioassessment Results - Lake Waveland Watershed
October 2000

	Site #					
	1	2	3	4	5	6
Chironomidae (Midges)						
Cricotopus bicinctus	2	7	4		3	
Orthocladius obumbratus	8	16	7		2	
Eukiefferiella bavarica	3	3			1	
Parametriocnemus lundbacki	6	12	23		4	2
Psectrocladius flavus	1	3			2	
Nanocladius rectinervus			1			
Tanytarsus glabratus	2					1
Ablabesmyia mallochi	2					
Simuliidae (Blackflies)	1					
Tipulidae (Craneflies)						
Tipula sp.	5	1	1			8
Antocha sp.	1				5	1
Ephemeroptera (Mayflies)						
Stenonema femoratum						15
S. vivarium						9
Caenis punctata						2
Isonychia sayi						4
Baetis brunneicolor						2
B. amplus	1					
B. flavistriga						2
Trichoptera (Caddisflies)						
Cheumatopsyche spp.			1			16
Hydropsyche betteni						1
Helicopsyche borealis						2
Plecoptera (Stoneflies)						
Amphinemura venosa	8					
Allocapnia sp.					20	
Odonata (Dragonflies)						
Enallagma spp.			5			
Somatochlora spp.	1	3				
Coleoptera (Beetles)						
Stenelmis crenata	3					
Stenelmis larvae	9	1	1		2	3
Dubiraphia larvae			2			
Coptotomus spp.					3	
Dytiscus larvae	2	2			7	

Table 3 (continued)
Rapid Bioassessment Results - Lake Waveland Watershed
October 2000

	Site #					
	1	2	3	4	5	6
Isopoda (Pillbugs)						
Caecidotea spp.	1					
Amphipoda						
Hyalella azteca	35	2			37	1
Gastropoda (Snails)						
Helisoma spp.	1	20				2
Physella gyrina	3	27	22		13	17
Gyraulus spp.						2
Lymnaea stagnalis			3			4
Pelycepoda (Clams)						
Sphaerium sp.	3		28			1
Turbellaria (Flatworms)						1
Hirudinea (Leeches)		1	2			2
Oligochaeta (Worms)						
Tubificidae	2	1				2
Lumbriculidae		1				
Naididae					1	
Total	100	100	100		100	100

Site 4 was not sampled during October

Table 4. Data Analysis for 10/00 Samples

METRICS

	Site # 1	2	3	4	5	6
# of Genera	21	15	13		13	21
Biotic Index	6.5	6.0	6.9		6.6	6.1
Scrapers/Filterers	4.5	55	1.0		18	2.5
EPT/Chironomids	0.4	0.0	0.0		1.7	18
% Dominant Taxon	35	27	28		37	17
EPT Index	2	0	1		1	7
Community Loss Index	0.4	0.9	1.0		1.2	0.0
% Shredders	17	0	1		80	14

SCORING

	Site # 1	2	3	4	5	6
# of Genera	6	4	4		4	6
Biotic Index	6	6	4		6	6
Scrapers/Filterers	6	6	4		6	6
EPT/Chironomids	0	0	0		0	6
% Dominant Taxon	2	4	4		2	6
EPT Index	0	0	0		0	6
Community Loss Index	6	4	4		4	6
% Shredders	6	0	0		6	6
TOTAL	32	22	20		28	48
% of Reference	67	46	42		58	100
Impairment Category	S	M	M		S	N

N = NONE S = SLIGHT M = MODERATE Sv = SEVERE

Summary of Aquatic Community Index Scores (Normalized to 100)

	Site 1	Site 2	Site 3	Site 4	Site 5	Watershed Average
May	**79**	**58**	**21**	**46**	**46**	**50**
October	**67**	**46**	**42**		**58**	**54**

DISCUSSION

Chemical parameters measured at each site indicate that dissolved oxygen (D.O.), pH, temperature, and conductivity fell within acceptable ranges for most forms of aquatic life. Abundant algal growth (stimulated by high nutrient inputs) is usually indicated by pH readings significantly higher than 8.0. This was true at all sample sites. High algal growth rates are also indicated at sites where dissolved oxygen is much higher than the saturation level. This was especially true at Demeree Creek (site 3), where the D.O. level was much higher than saturation during both sampling periods. Because algae also use oxygen when light is not present, sites with abundant algae typically have large variations in D.O. During the night or on cloudy days the D.O. at such sites may drop below the 5 mg/l minimum required for healthy aquatic communities.

A total of 29 macroinvertebrate genera were collected at the six sites during May, while 38 genera were collected during October. The most commonly collected invertebrates at the five study sites were midge larvae, aquatic beetles, and snails. The pollution intolerant groups Ephemeroptera, Plecoptera, and Trichoptera (mayflies, stoneflies, and caddisflies) were abundant only at the reference site and at site 1 on Old Shoe Branch in May.

Tables 2 and 4 shows how the aquatic communities at the five study sites compared to that of the reference site. Impacted sites are shown graphically in Figure 4. The stream's impairments ranged from "slight" in Old Shoe Branch during both study periods to "severe" in Demeree Creek in May.

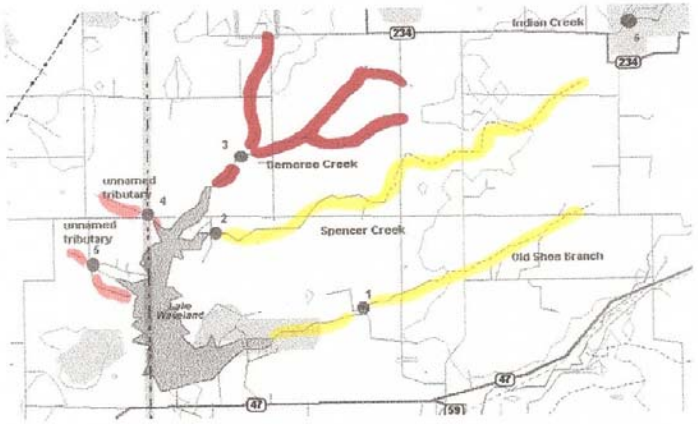
Figure 5 shows the normal relationship of biotic index scores to habitat values (a linear relationship according to [4]). The figure also shows a range of plus or minus 10% to account for a certain amount of measurement variability. When biotic index values fall outside this range, the site typically has degraded water quality. Figure 4 indicates that none of the study sites had biotic values within the range expected from its measured habitat value. Therefore, the lower than expected biotic values are both water quality and habitat degradation.

The largest deviation from the expected value occurred at sites 2 and 3 on Demeree Creek and Spencer Creek. Efforts to increase water quality in the Lake Waveland watershed should be focused on these areas.

Figure 4.
Degrees of Biological Impairment in the Lake Waveland Watershed

Yellow = Slight Impairment
Orange = Moderate Impairment
Red = Severe Impairment

May 2000



October 2000

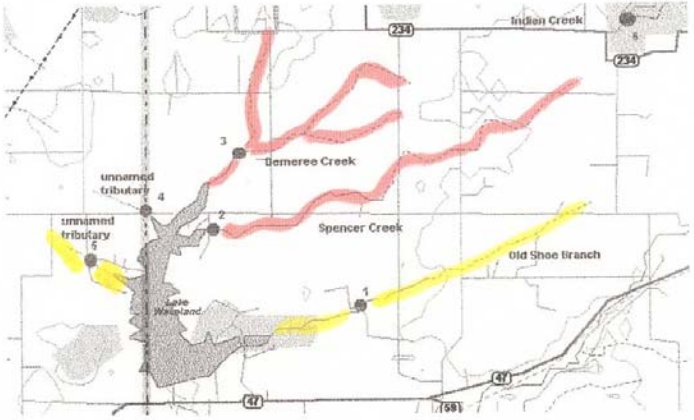
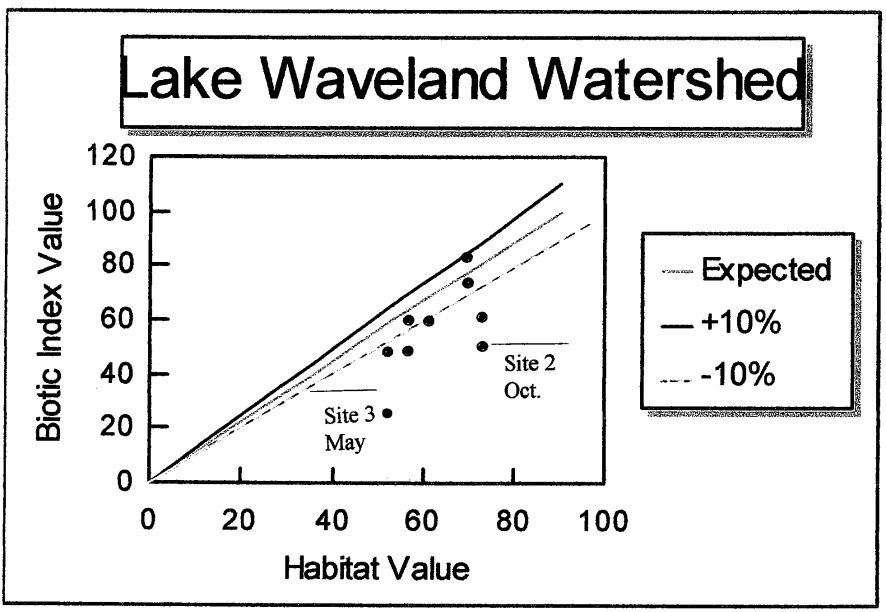


Figure 5.

The normal relationship between habitat and biotic index score is shown below. Sites falling outside the normal relationship (plus or minus 10%) are probably affected by degraded water quality.



The biotic index scores did not differ greatly from May to October at most sites. Water quality at site 3 (Demeree Creek) appeared to be better in October (moderate impact) than it was in May (severe impact). This difference was due primarily to a lower Hilsenhoff Biotic Index (HBI) value and fewer pollution-tolerant midges during October. The HBI is sensitive to changes in dissolved oxygen, so dissolved oxygen levels in Demeree Creek may have increased after May.

Table 4 shows sediment-tolerance values for many of the commonly collected animals in these streams. The proportion of sediment and turbidity-intolerant forms was much higher at the reference site than at any of the study sites. These results indicate that sediment-related impairment may be contributing to the water quality problems in the Lake Waveland watershed. This is especially true in Spencer Creek and Demeree Creek (sites 2 and 3), where almost no sediment-intolerant forms of life were found.

Table 4. Sediment-Intolerant Species Observed
(Literature references to the species as an indicator are shown in brackets)

Stenonema vivarium	[10] [15]
Stenonema femoratum	[10] [15]
Plecoptera	[10]
Hyalella azteca	[10]
Tipula spp.	[10]
Antocha spp.	[10]

		May	Oct.
% of Sediment-Intolerant Organisms at the Reference		28%	21%
% of Sediment-Intolerant Organisms at the Study Sites			
	Site 1	23%	49%
	Site 2	0%	3%
	Site 3	1%	1%
	Site 4	0%	No sample
	Site 5	10%	62%

Another problem observed in the watershed was an apparent discharge of dairy waste into the tributary at site 4. During the May sampling period, this tributary was milky white from a discharge into a tile along the Parke/Montgomery County Line Road (see photograph in the Appendix). This discharge should be eliminated a quickly as possible to keep milk-related pollution (a contributor to excess nutrients and low dissolved oxygen) out of Lake Waveland.

RECOMMENDATIONS

1. **Concentrate on application of best management practices and land treatments in the Demeree Creek watershed, where the greatest impairment was observed. Also pay special attention to Spencer Creek, which already has adequate habitat to support a diverse aquatic community but which has significantly impaired water quality from excessive sediment inputs.**

2. **Eliminate the discharge of dairy waste to the unnamed tributary at site 4.**

3. **Work toward continued protection of the vegetative buffer zone along the stream corridors. Tree plantings along streams should be encouraged for shading.**

4. **Discourage channelization of the stream. Minimizing channelization allows the streams to retain a natural channel that enhances aquatic habitat.**

5. **Discourage direct access to the streams by livestock. Large numbers of livestock can trample stream banks, decreasing the ability of streamside vegetation to filter out pollutants and hastening erosion.**

6. **Consider a bank stabilization program on some of the headwater streams. Use vegetative stabilization techniques rather than rip-rap whenever possible.**

7. **Continue to monitor the watershed every three to five years to determine whether conditions improve as the project is implemented. A single sampling season is enough to provide useful information for this purpose.**

8. **Continue to encourage volunteer monitoring in the watershed. Such programs provide invaluable educational opportunities and give participants a sense of ownership in the water quality improvements observed over the years.**

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Habitat Scoring Results

	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
SUBSTRATE	8	8	5	8	8	14
COVER	6	6	2	6	6	11
CHANNEL	13	13	6	12	10	15
RIPARIAN	12	15	9	11	10	17
POOL/RIFFLE	7	10	9	7	7	13
GRADIENT	8	6	8	4	4	8
DRAINAGE AREA	5	5	5	4	4	9
TOTAL	59	63	44	52	49	87

COMMONWEALTH BIOMONITORING
Macroinvertebrate Identification Literature

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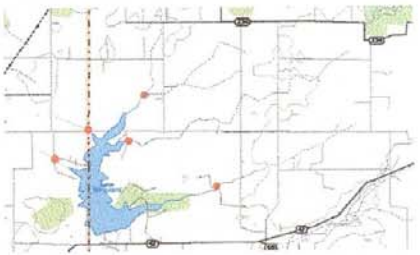
BIOASSESSMENT SUMMARY
LAKE WAVELAND WATERSHED

Purpose

To measure the water quality of the Lake Waveland watershed by looking at the kinds of animals which live there.

Watershed Characteristics

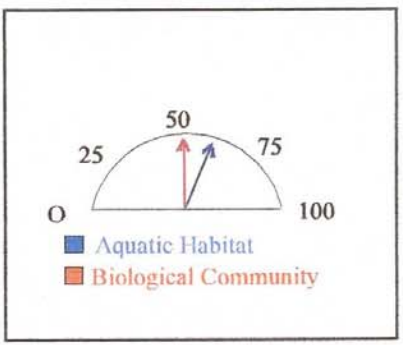
The watershed is predominantly agricultural. Several streams have been severely channelized.



Results

The biological community and aquatic habitat of five streams in the Lake Waveland watershed are less than optimal. Sediment tolerant forms of life are dominant. Excessive nutrient inputs favor conditions for algae growth. Demeree Creek is especially impacted.

Water Quality Meter
A score of 100 is our goal



Definitions

Aquatic Habitat - physical characters which support life (shade, cover, stream bottom, food sources, etc.)

Biological Community - the kinds of animals living in a stream. High quality streams have many different kinds, including those intolerant to changes in habitat & water pollution.

May 2000
Commonwealth Biomonitoring
8061 Windham Lake Drive, Indianapolis, Indiana 46214

Lake Waveland Watershed - Water Quality Monitoring Sites

Unnamed tributary on west side of lake, with milk discharge

Milk discharge through pipes

Demeree Creek on north side of lake showing lack of shade and extreme channelization

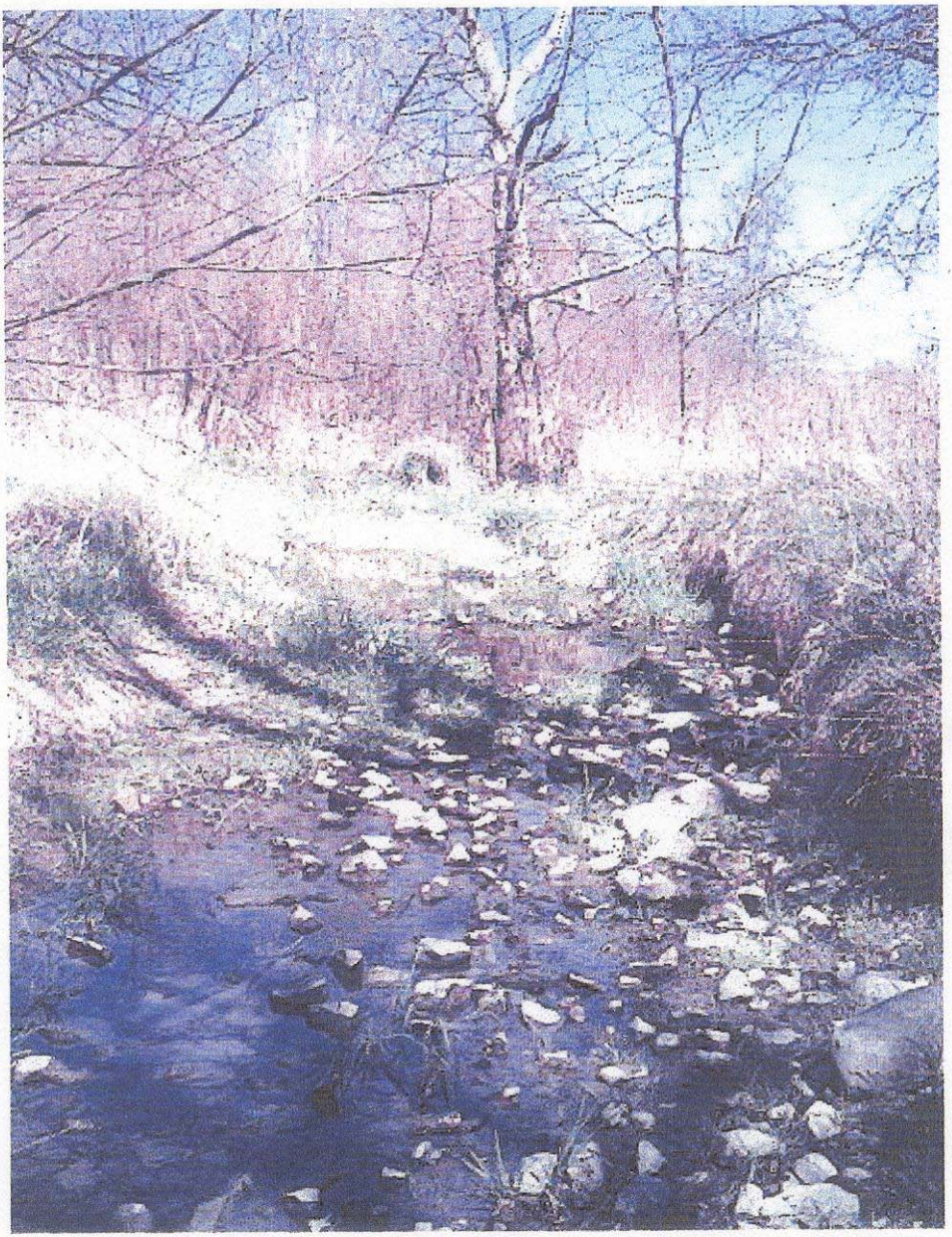
Bluegreen algae bloom in Demeree Creek

Indian Creek (reference site) showing good habitat and biological community

Reference Stream
Indian Creek near Pine Hills Natural Area (Montgomery County)

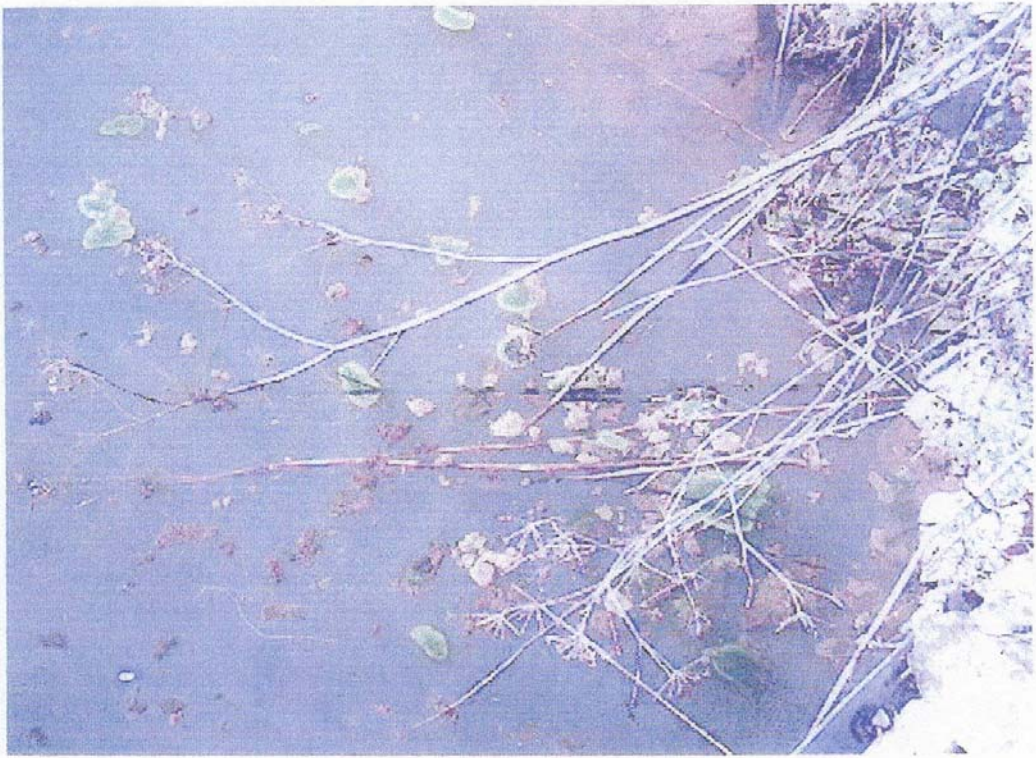
Site 1
Old Shoe Branch on southeast side of Lake Waveland

Site 2
Spencer Creek on northeast side of Lake Waveland



Site 3
Demeree Creek on north side of Lake Waveland

Site 3
Bluegreen algae bloom on Demeree Creek



Site 4
Unnamed Tributary on northwest side of Lake Waveland

Site 5

Unnamed tributary on the southwest side of Lake Waveland